

# **Performance of EC-Earth climate forecast system and generation of new sea ice initial conditions**

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In collaboration with:

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Du, Javier Garcìa-Serrano

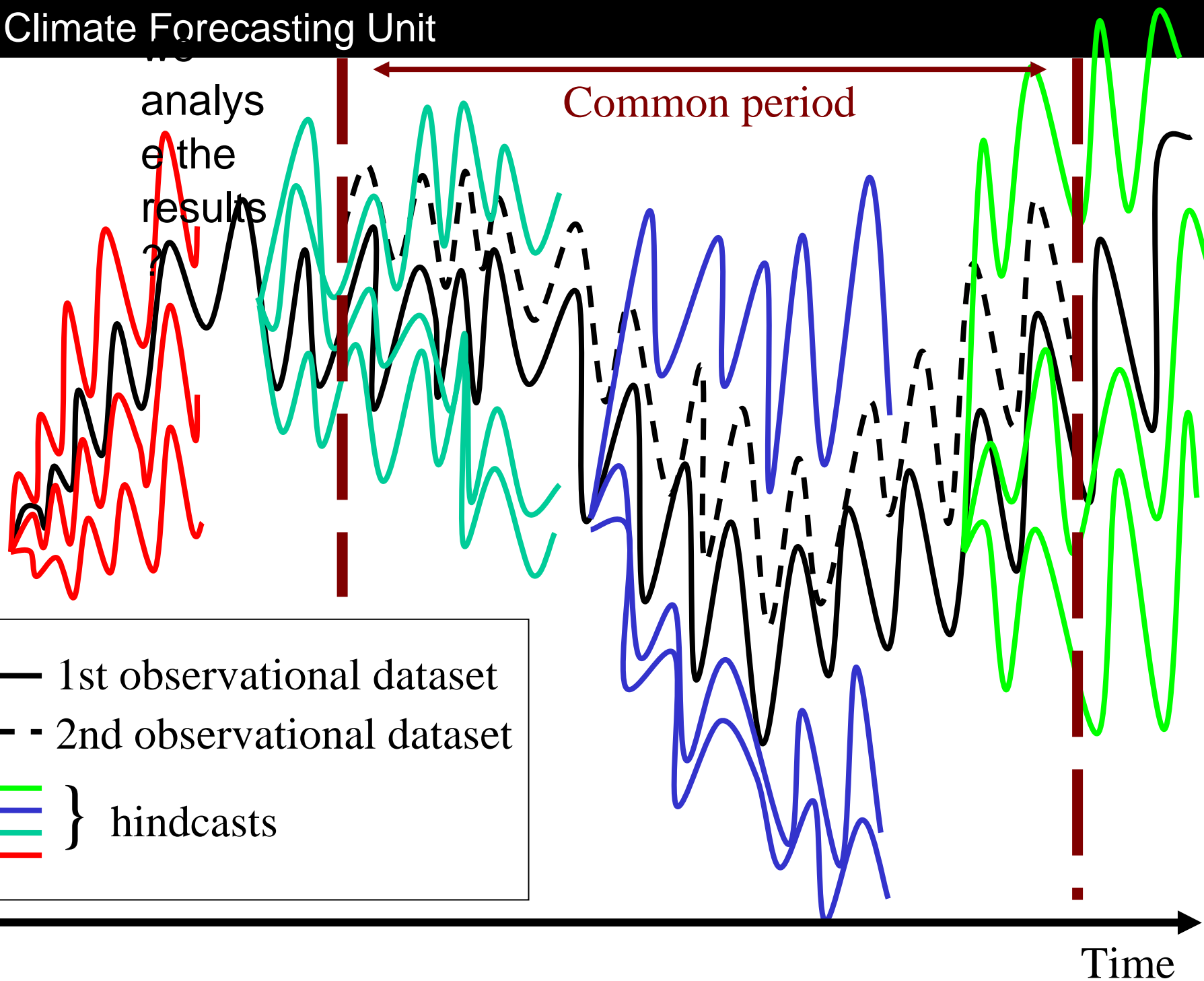
## Which experimental design?

A – Yearly hindcasts – 5 members – 10 year long :  **Init**

- Ocean initialized from the 5 members of NEMOVAR-S4 (Mogensen et al 2012)
- Atmosphere initialized from ERA40 / ERA interim, perturbation singular vectors
- Sea ice initialized from an NEMO2/LIM2 simulation forced with DFS4

### FULL FIELD INITIALIZATION

B - Historical simulation – 3 members – 1950-2025  **NoInit**

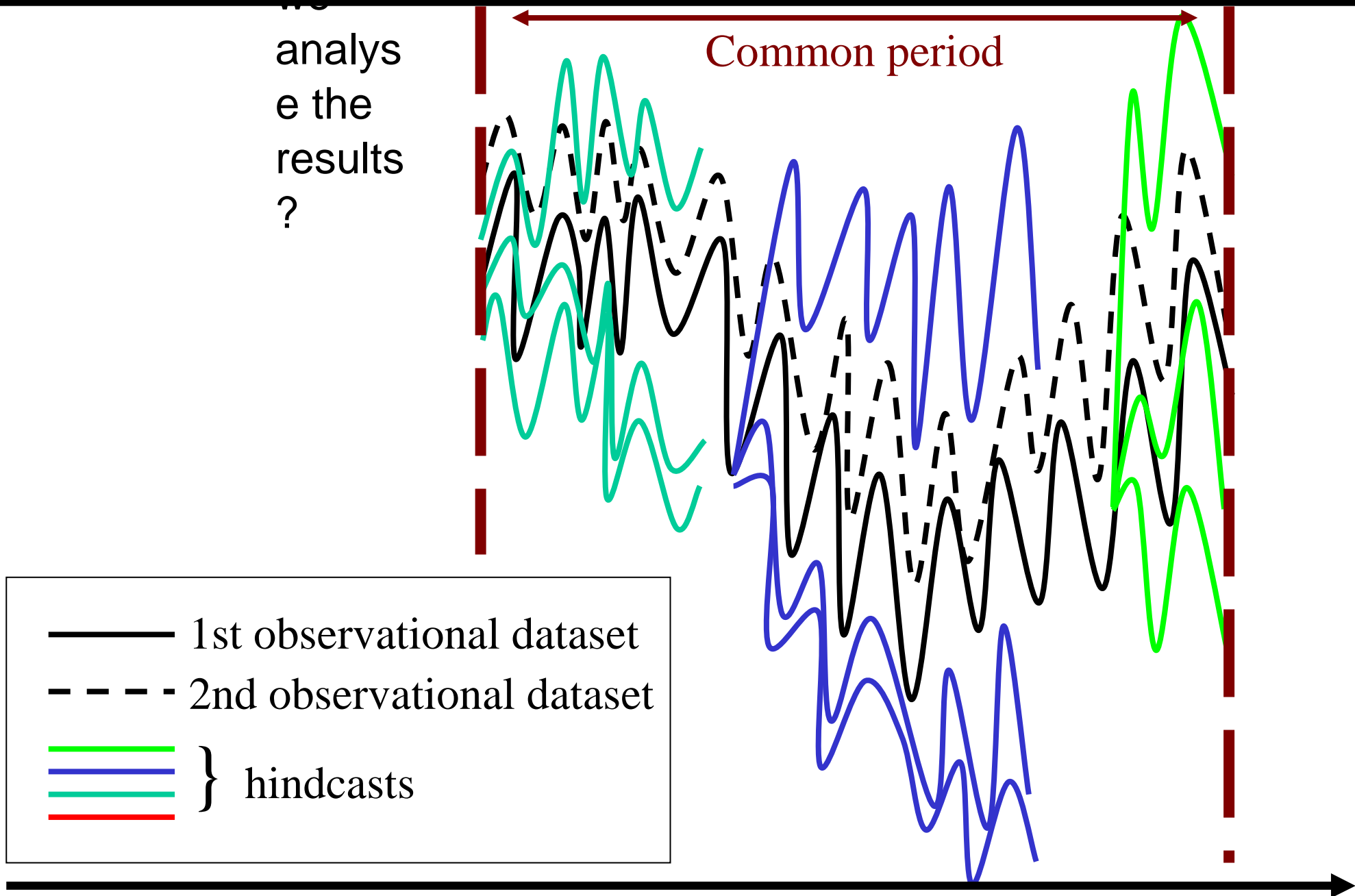


we  
analyse the  
results  
?

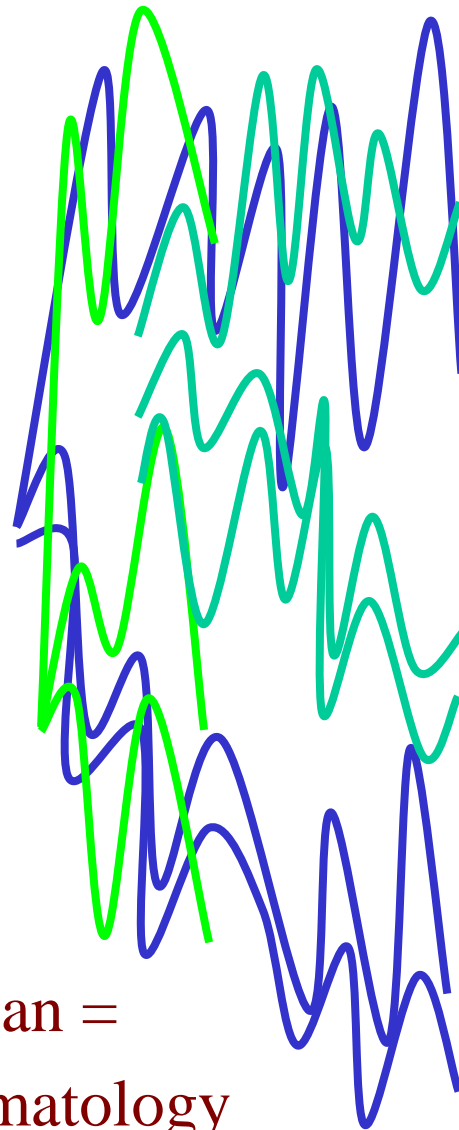
Common period

- 1st observational dataset
- - - 2nd observational dataset
- } hindcasts

Time




analys  
e the  
results  
?



Mean =  
climatology  
of the hindcasts

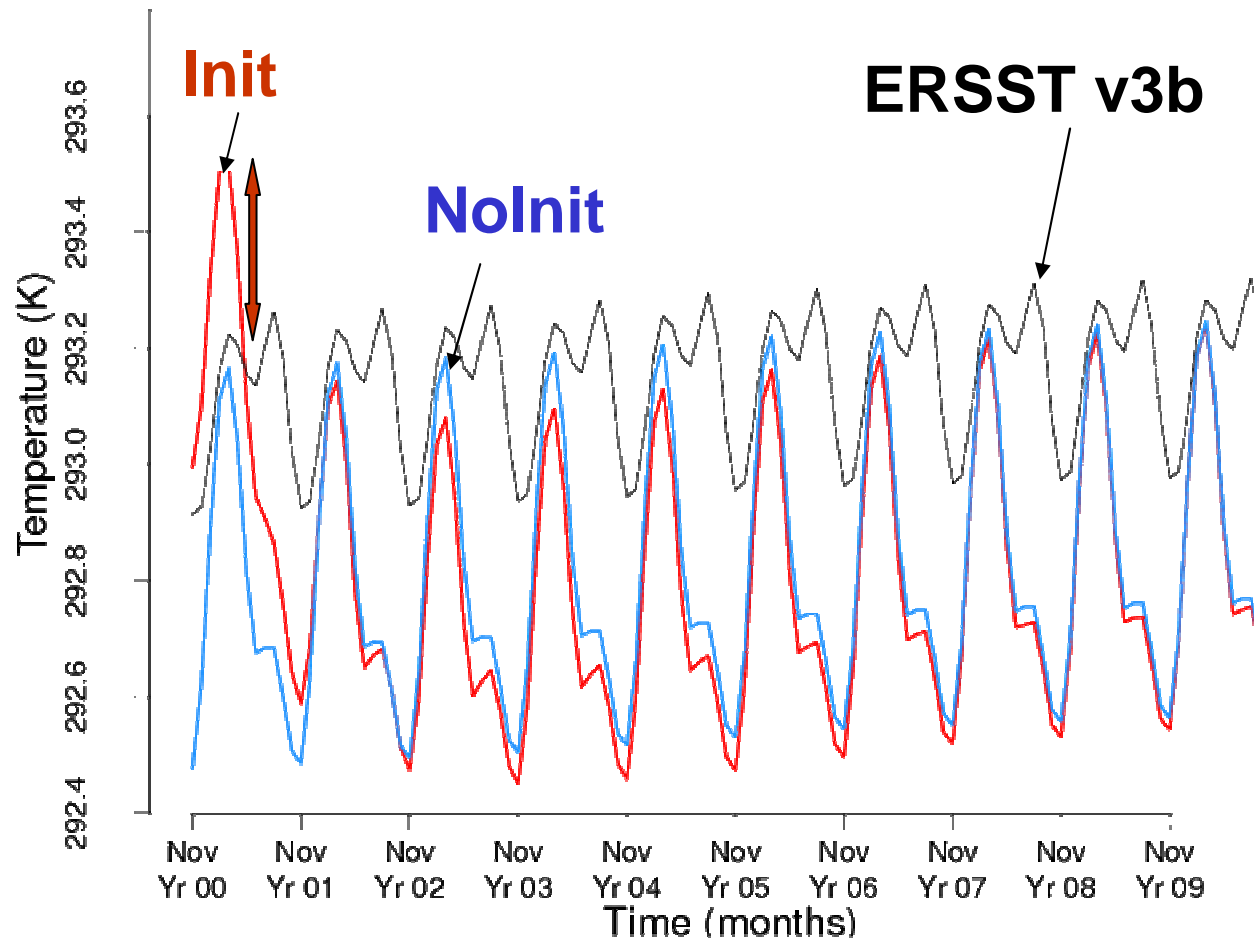
## How do we analyse the results ?

Anomalies = Raw-data - Observations/reanalyses or hindcast climatologies  over the whole period, not only the common one :

- 1) Global sea surface temperature
- 2) Atlantic Meridional Overturning Circulation Index
- 3) Atlantic Multidecadal Variability Index
- 4) Arctic Sea ice area

# Global Sea Surface Temperature (60S-65N)

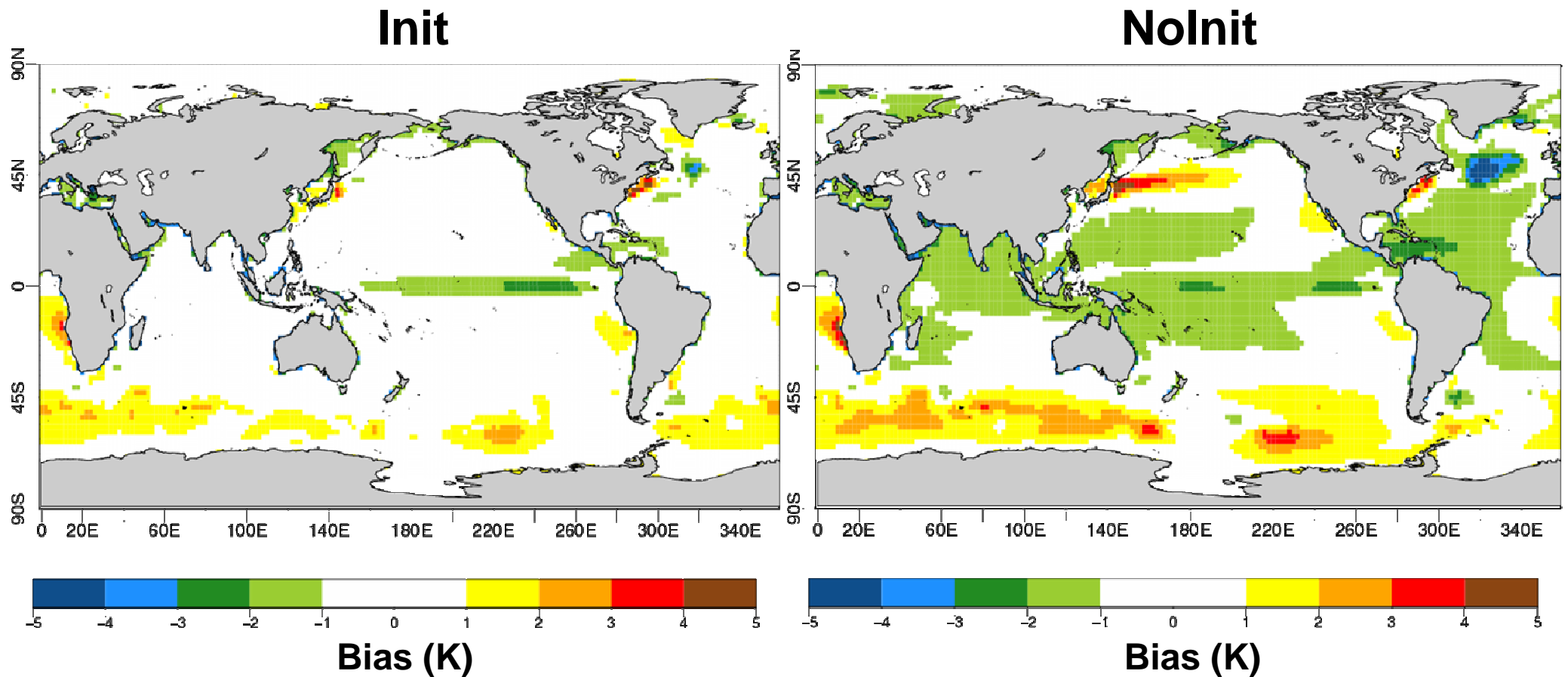
Climatology



➡ Initial warming : 0.3K, then after 2<sup>nd</sup> year, Init cooler than NoInit

# Sea Surface Temperature **bias** - yearly hindcasts

## Forecast time : 1<sup>st</sup> year



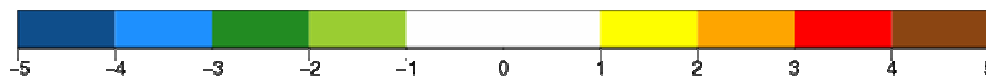
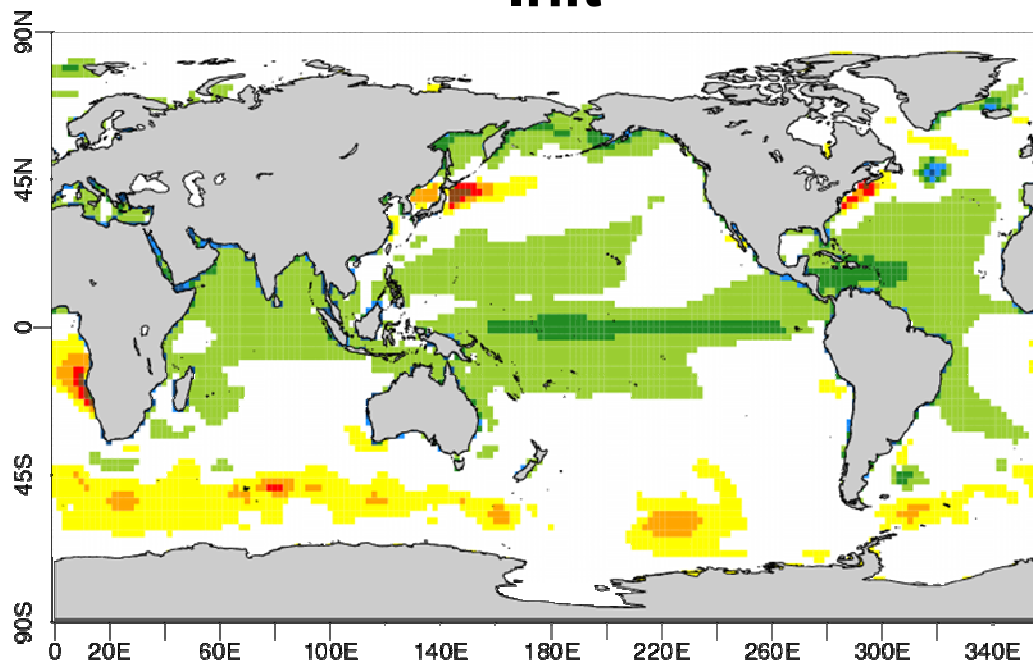
➡ Early development of the warm Austral bias



# Sea Surface Temperature **bias** - yearly hindcasts

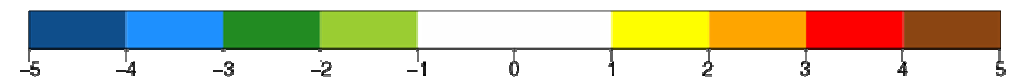
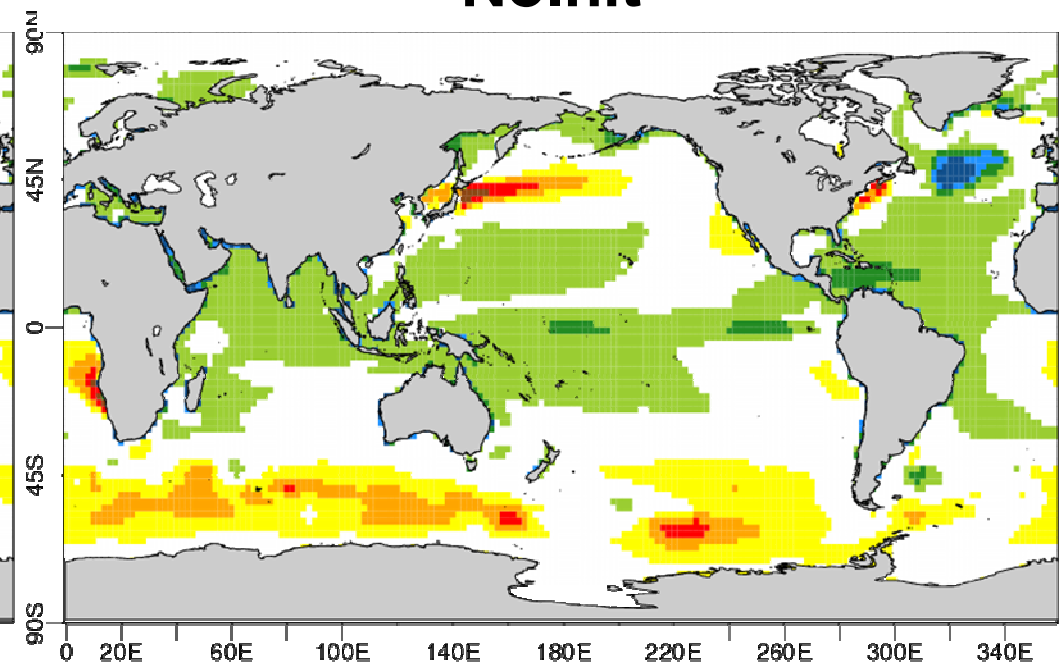
## Forecast time : 2-5 years

Init



Bias (K)

NoInit



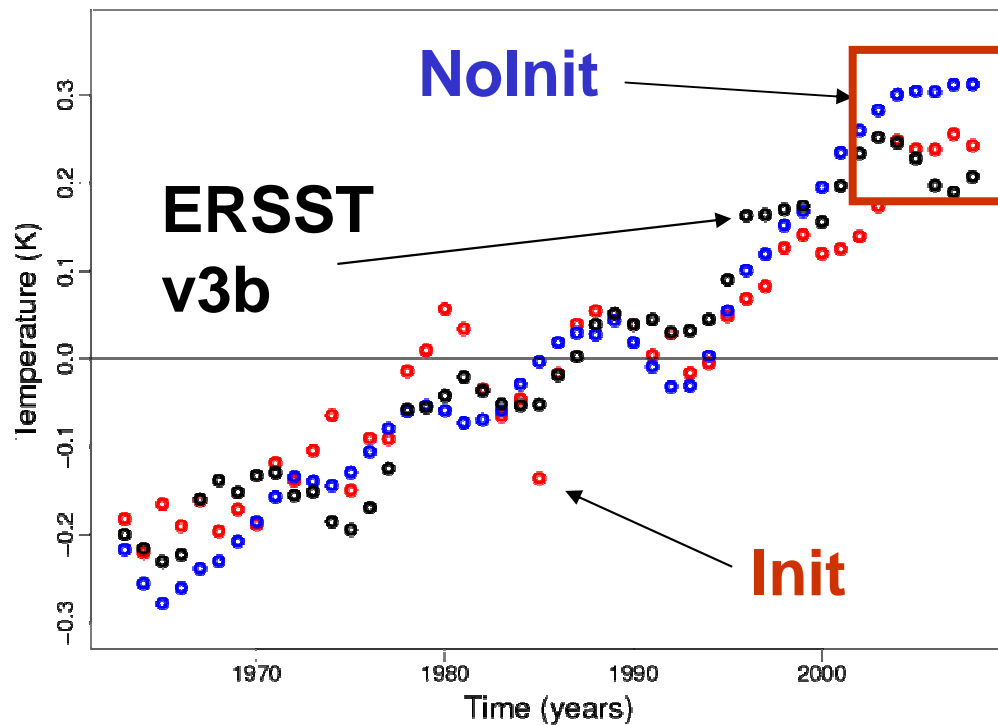
Bias (K)

➡ Tropical band cooler in Init than NoInit

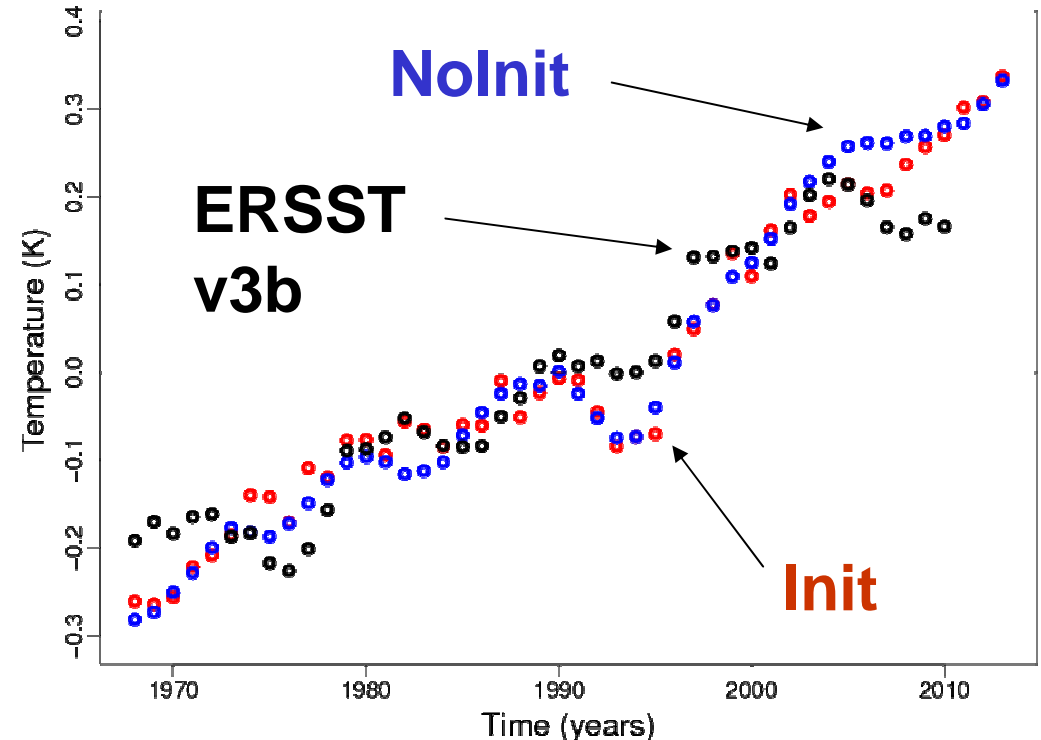
# Global Sea Surface Temperature (60S-65N)

Anomalies

Forecast times : 2 - 5 years



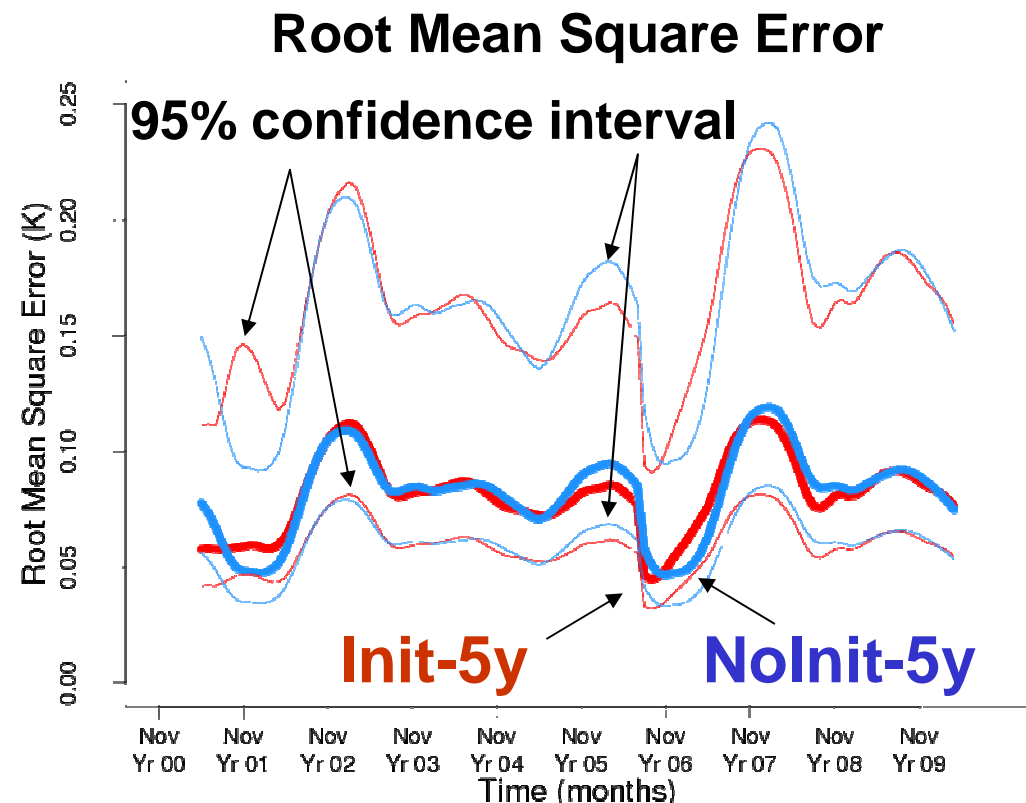
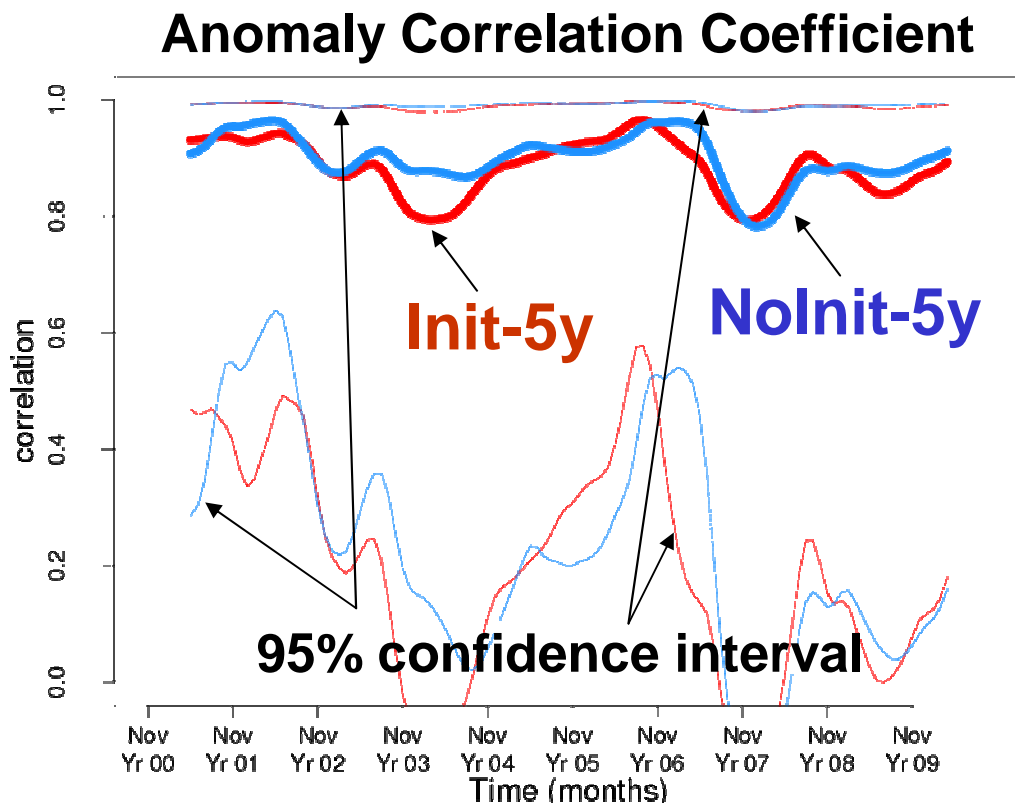
Forecast times : 6 - 9 years



- ➡ Benefits from initialization in the last decade – ARGO profiles
- ➡ Init tends to converge toward NoInit for forecast times 6-9 years

# Global Sea Surface Temperature (60S-65N)

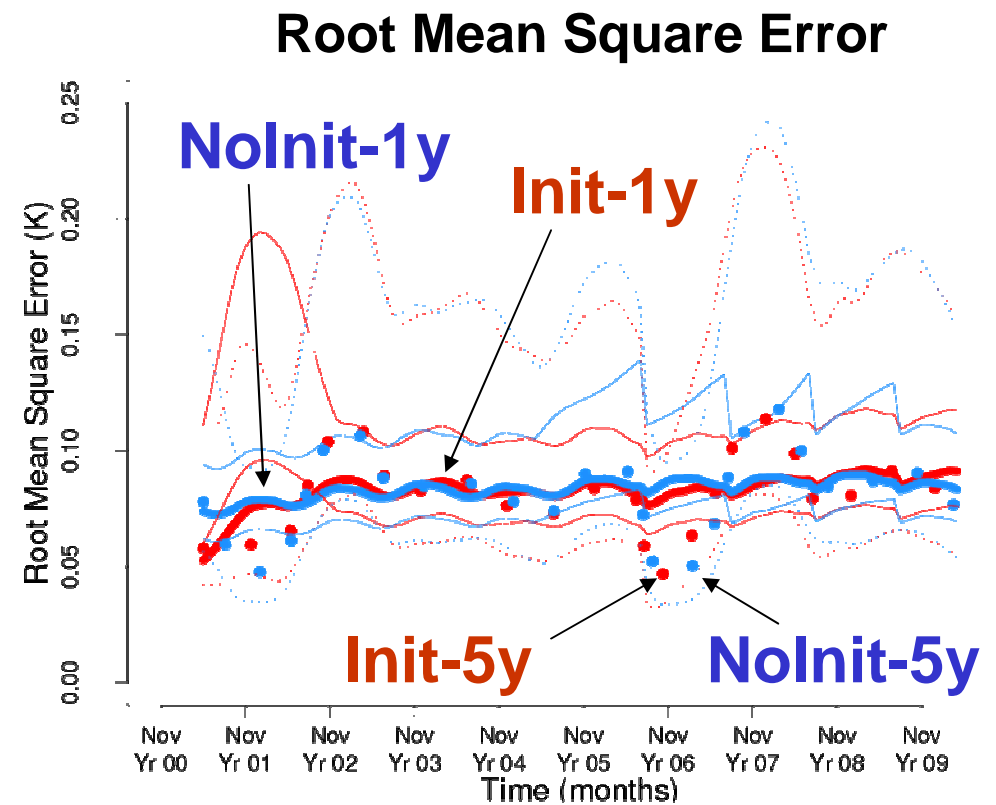
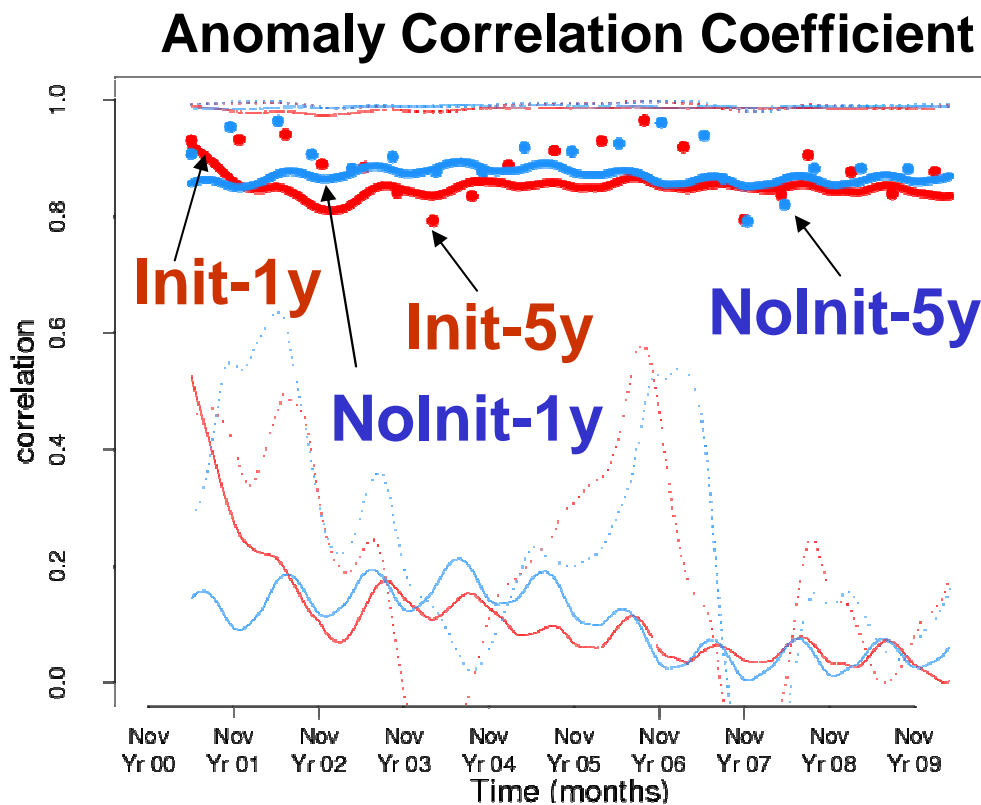
If we use 5-year hindcasts (=CMIP5 setup):



➡ Noisy scores, benefit from initialisation barely distinguishable

# Global Sea Surface Temperature (60S-65N)

If we use yearly hindcasts:

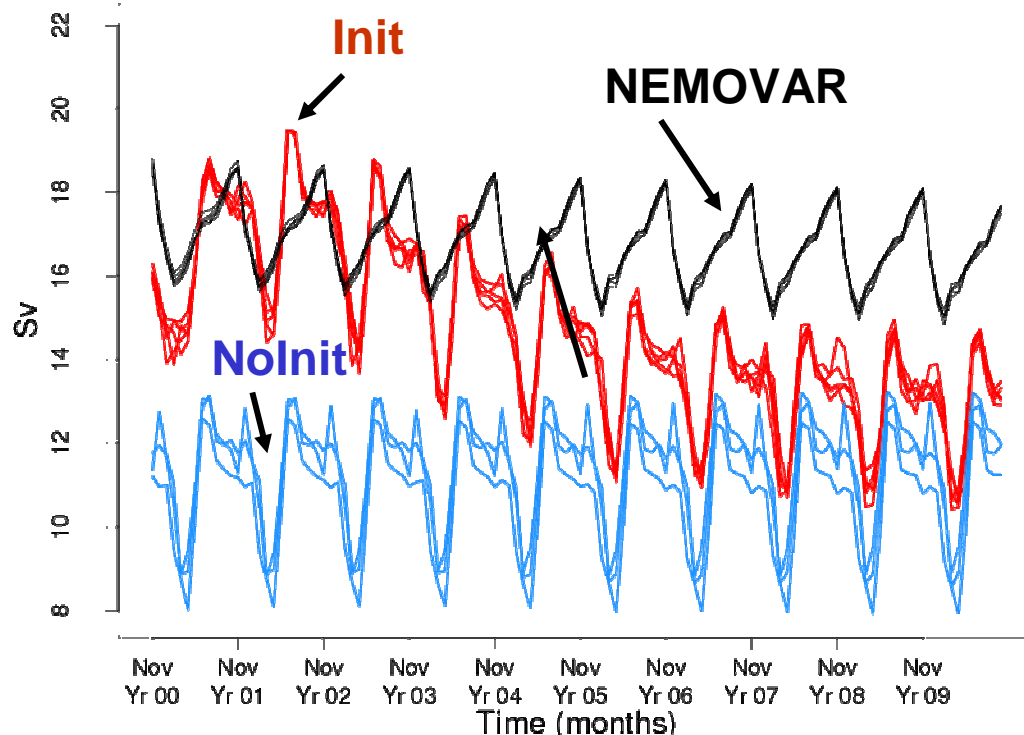


➡ With yearly hindcasts, it becomes possible to detect a benefit from the initialisation during the first year

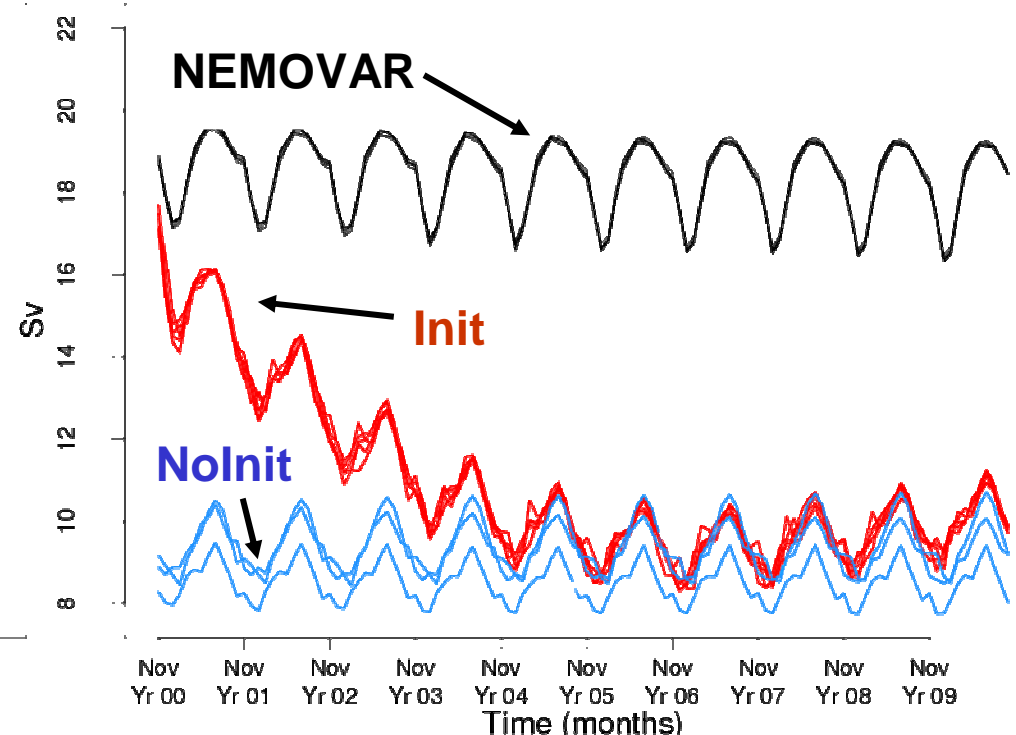
# Atlantic Meridional Overturning Circulation

Climatology

AMOC 30N-40N 1-2km



AMOC 40N-55N 1-2km

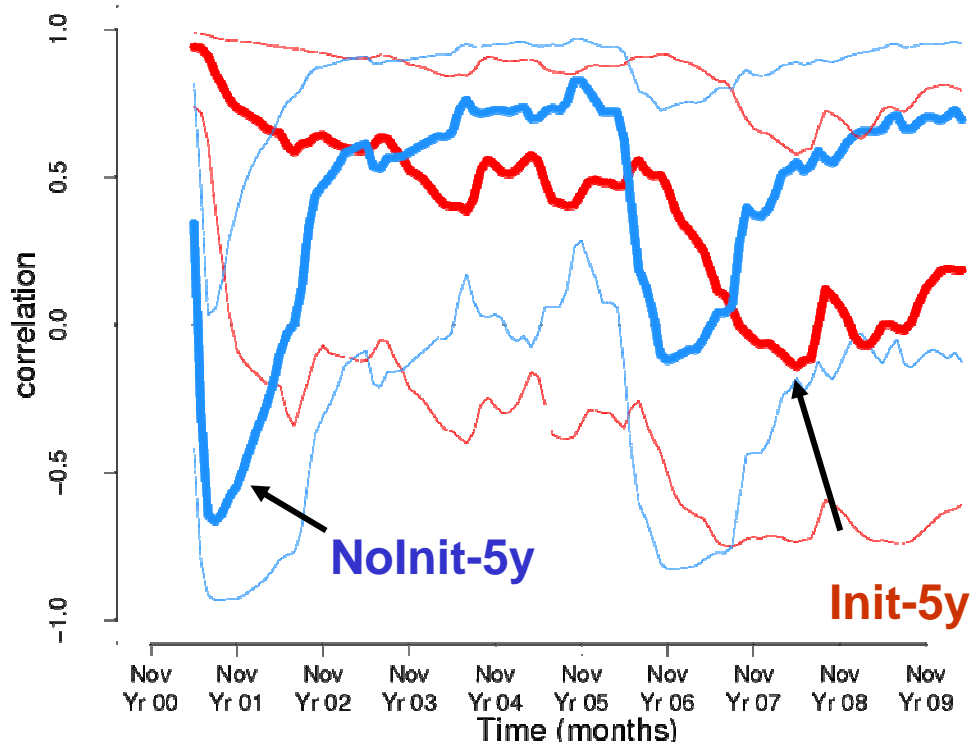


➡ Very strong drift, very weak AMOC

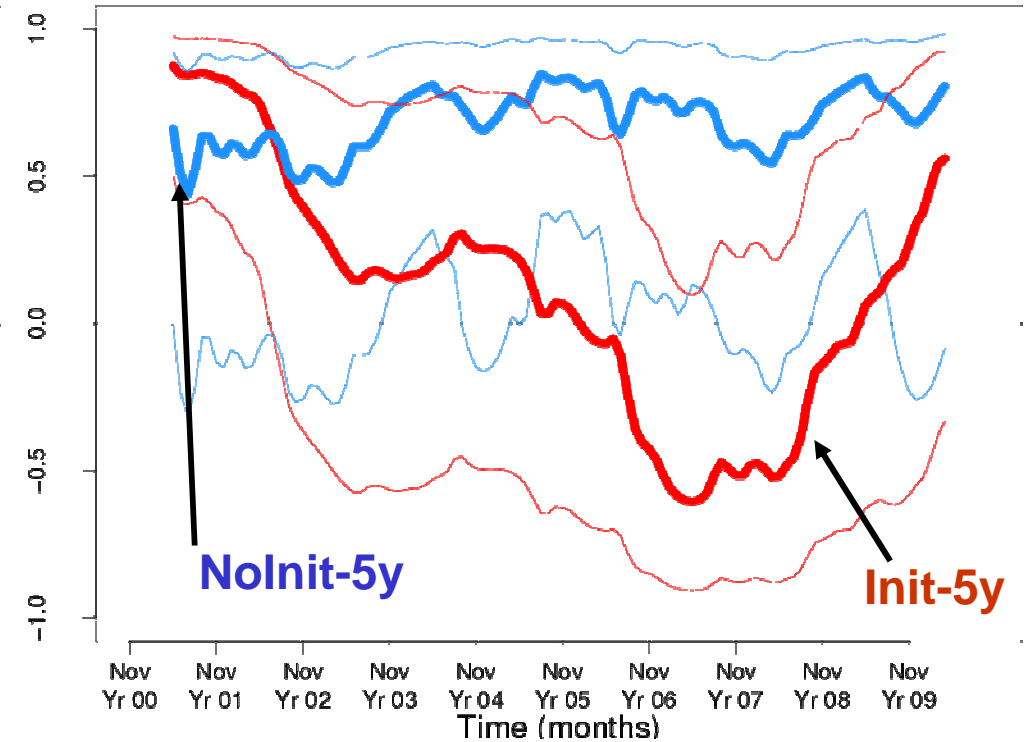
# Atlantic Meridional Overturning Circulation

If we use 5-year hindcasts (=CMIP5 setup):

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ACC AMOC 40N-55N 1-2km

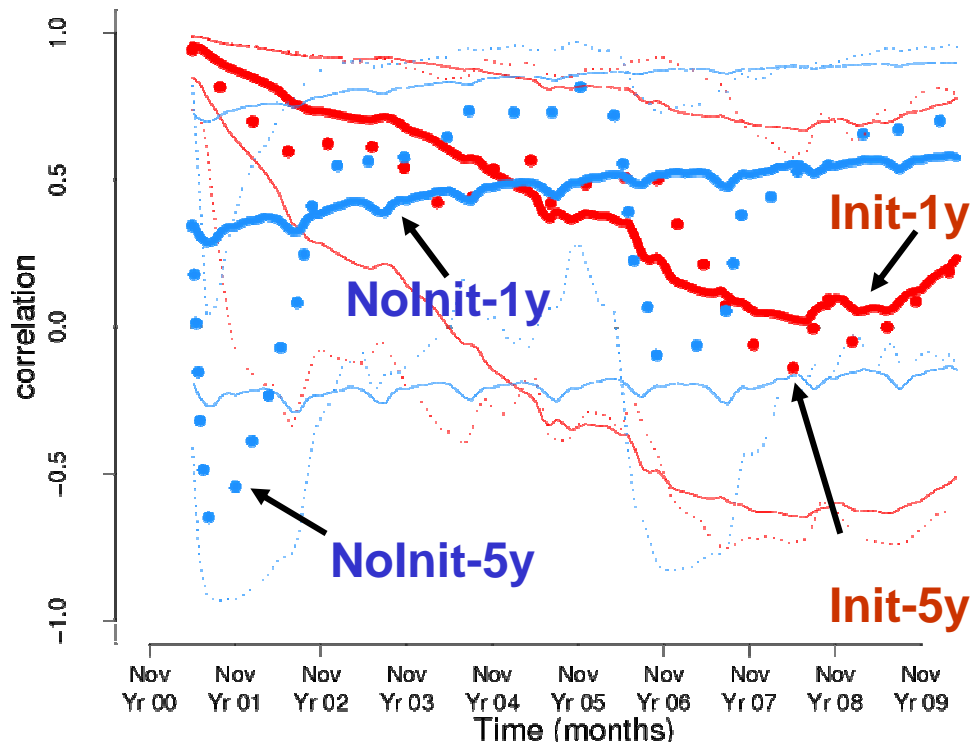


➡ Noisy scores, benefit from initialisation barely distinguishable

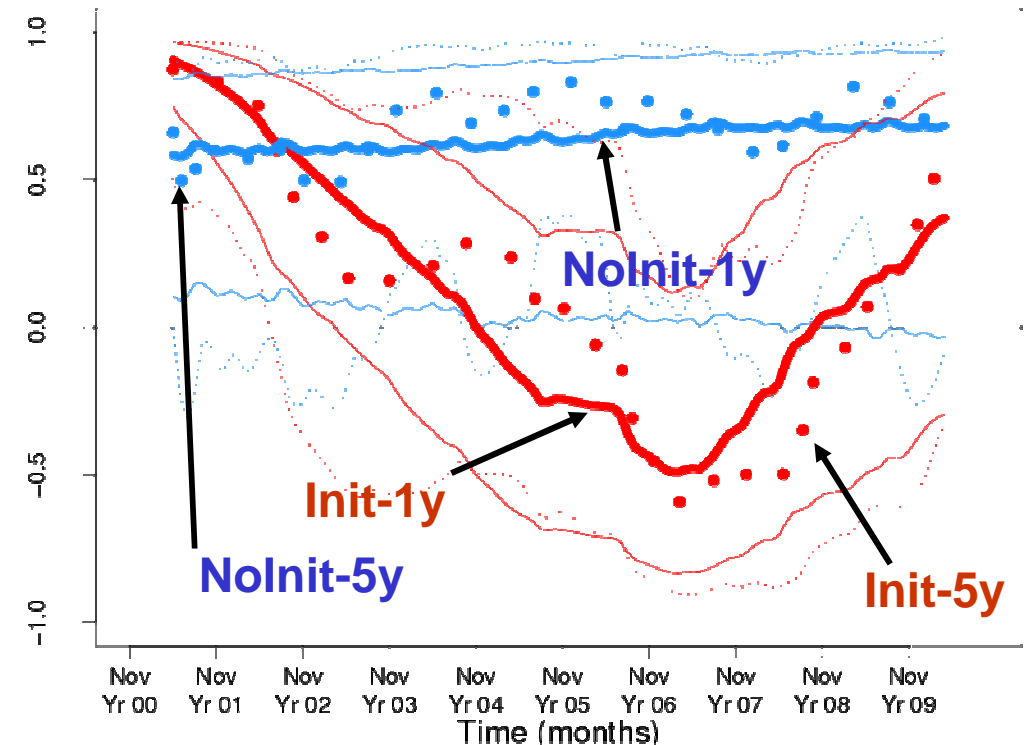
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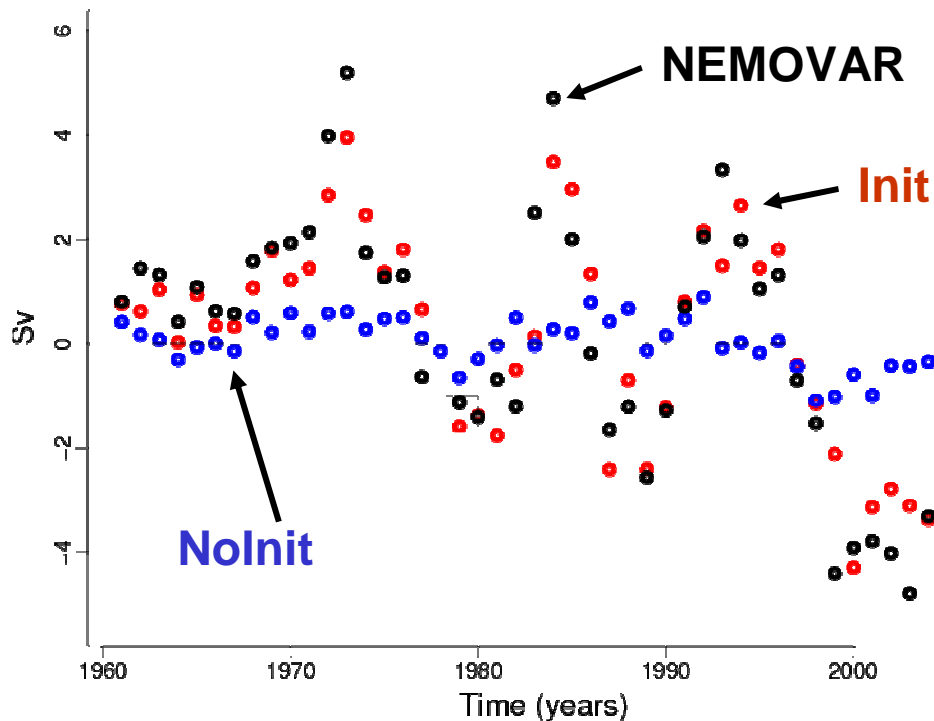


➡ Significant AMOC skill for 3 years in Init

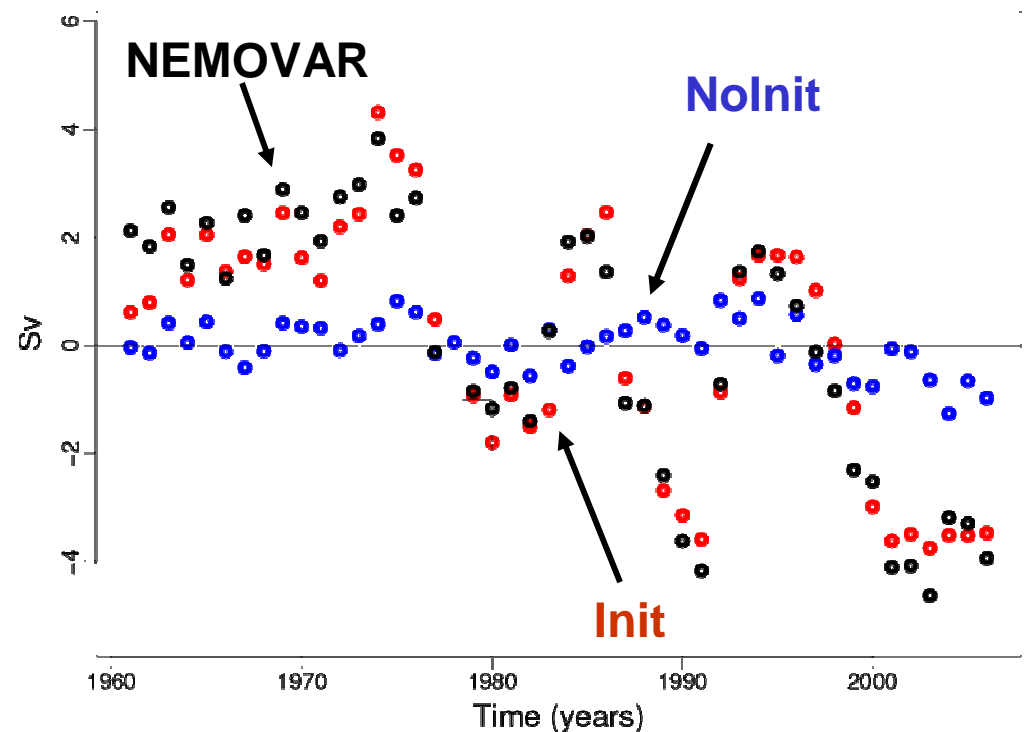
# Atlantic Meridional Overturning Circulation

Anomalies : Forecast times 1st year

AMOC 30N-40N 1-2km



AMOC 40N-55N 1-2km



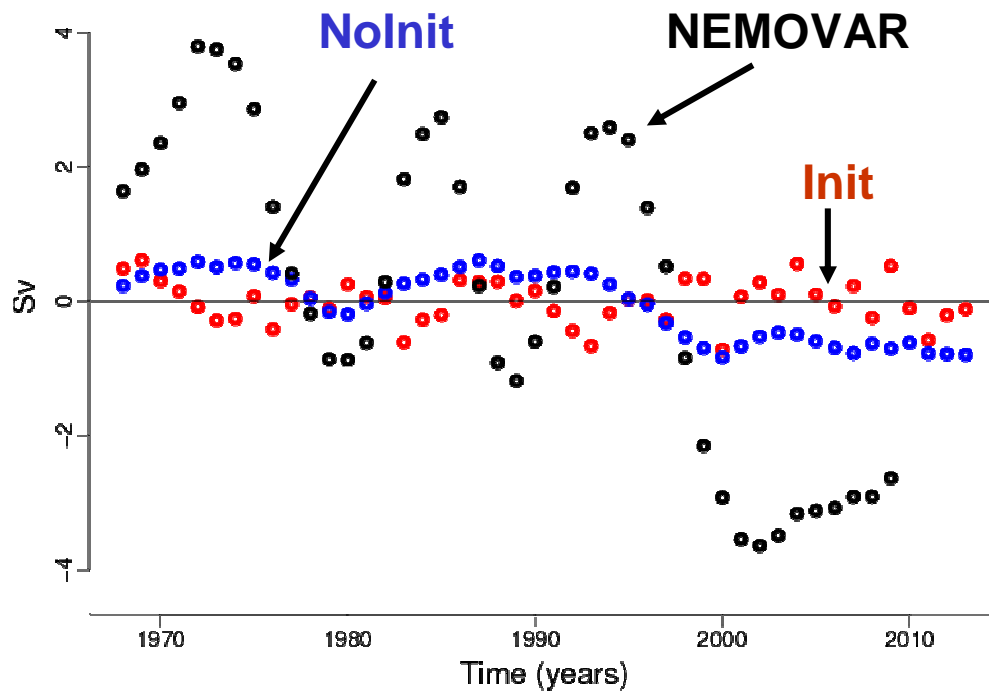
➡ Persistence / slight damping of the initial anomaly



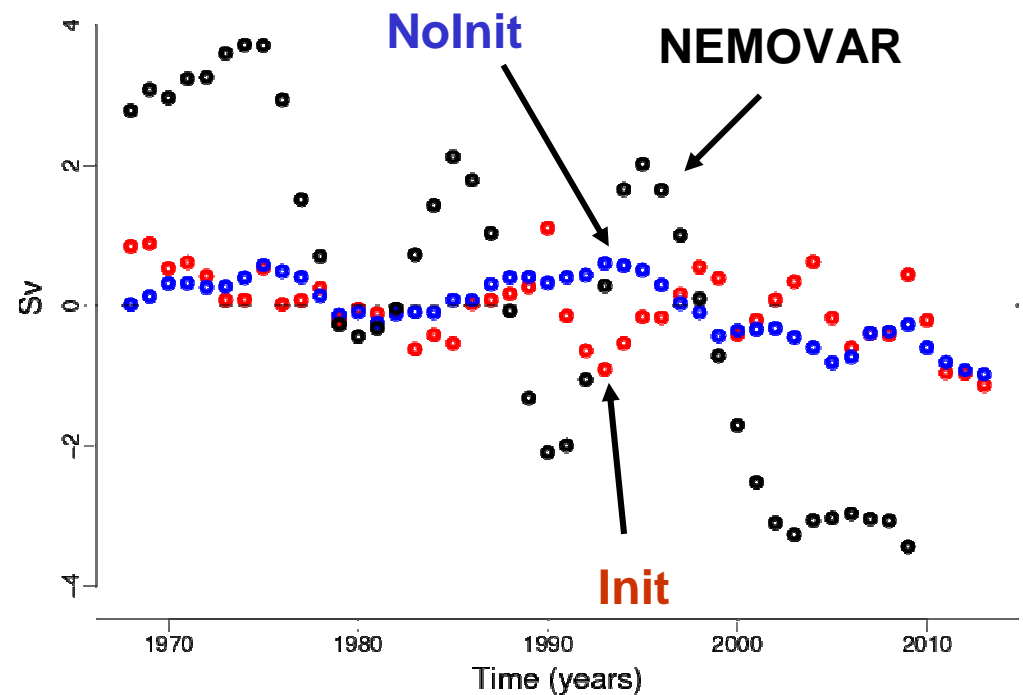
# Atlantic Meridional Overturning Circulation

Anomalies : Forecast times 6-9 years

AMOC 30N-40N 1-2km



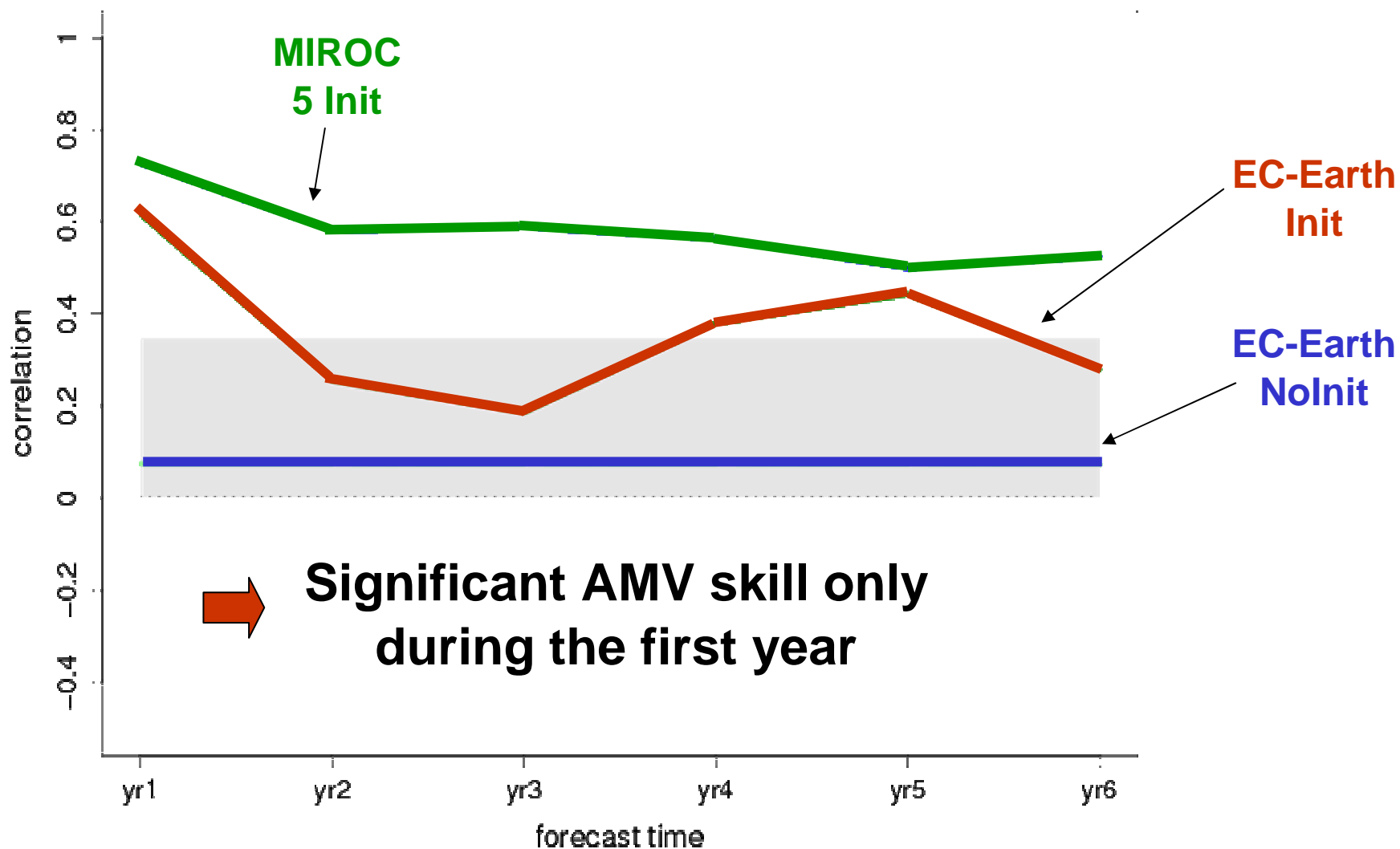
AMOC 40N-55N 1-2km



➡ Very bad performances for both Init and Noinit after a few years

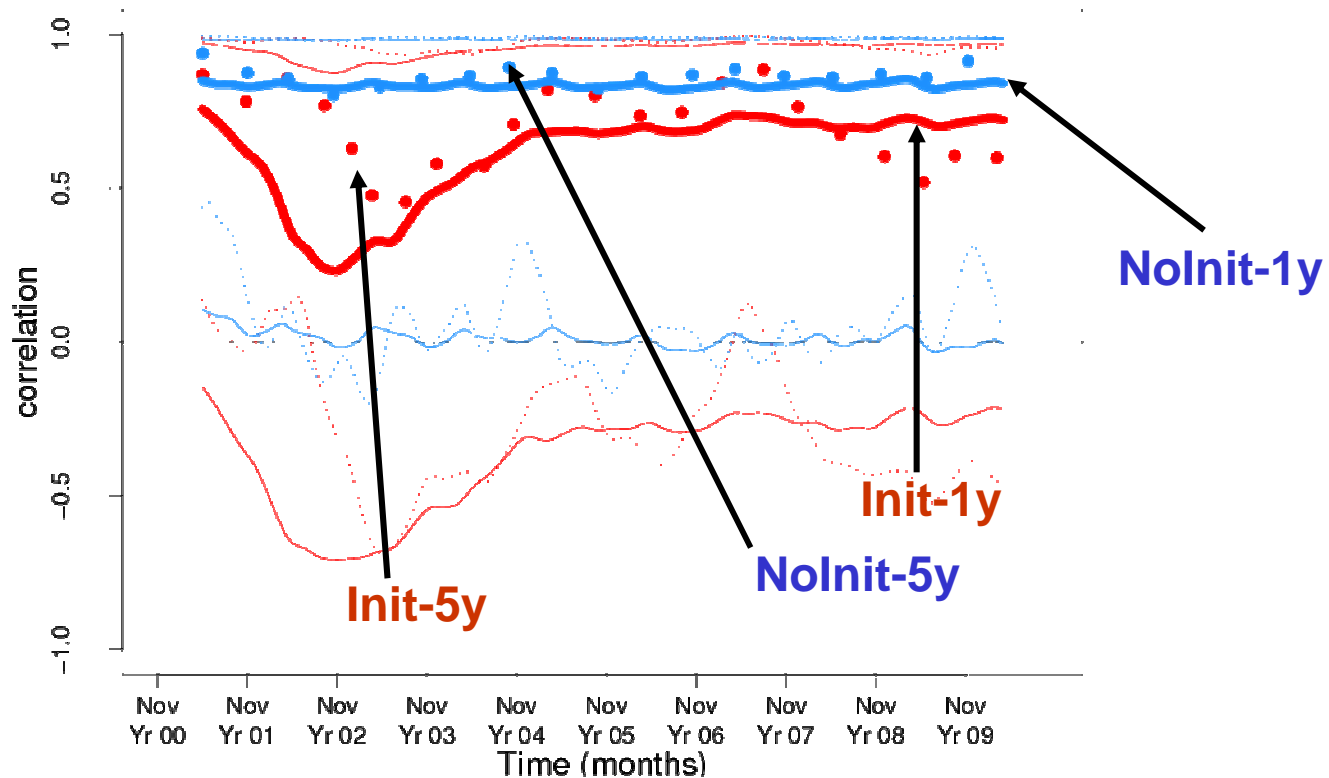
# Atlantic Multidecadal Variability Index

ACC annual AMV index



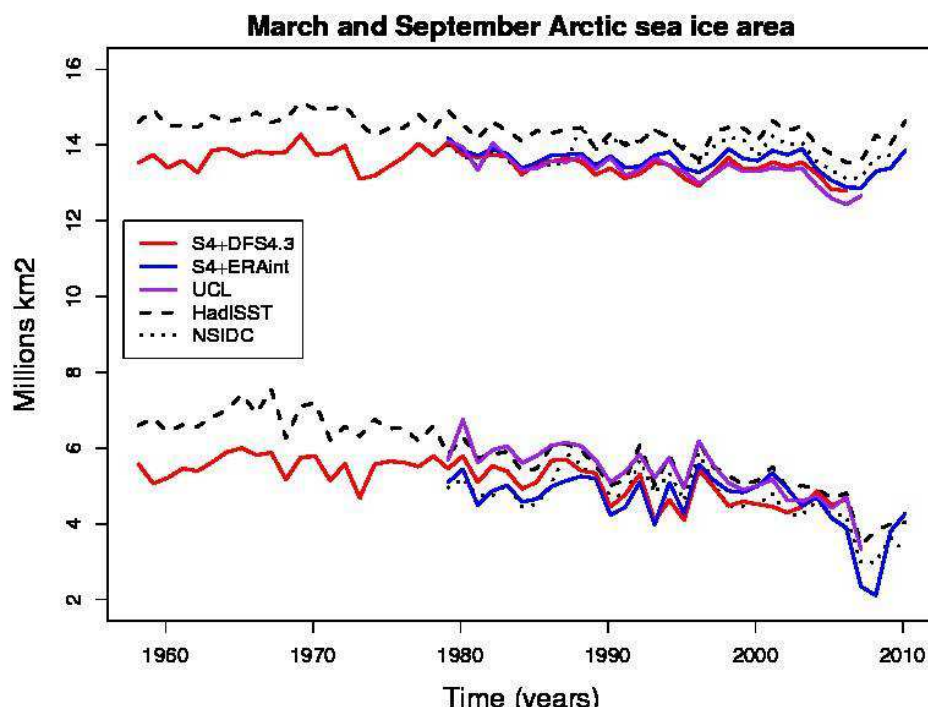
## Arctic sea ice area

### ACC Arctic sea ice area

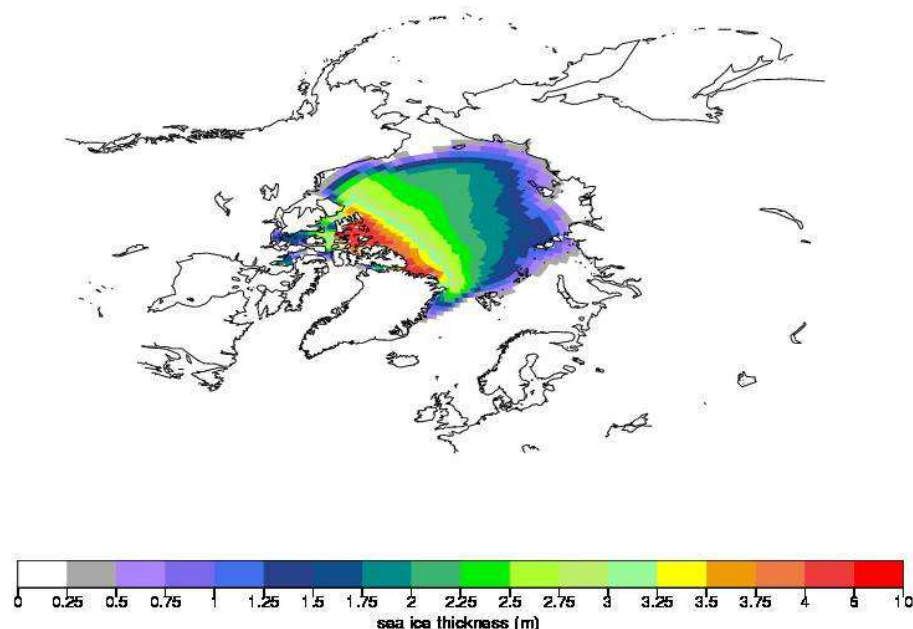


➡ Poor skill, crucial need for improved initial sea ice conditions

# Generation of sea ice initial conditions for seasonal to decadal climate predictions



September sea ice thickness (m)



- 1958-2006 and 1979-2010 \* 5-member strongly constrained sea ice historical simulation
- NEMO3.2/LIM2 forced DFS4.3/ERAinterim + wind perturbations (ENSEMBLES method)
- Nudged toward NEMOVAR-S4 5 members

➡ ORCA1 monthly restarts on request : [vguemas@ic3.cat](mailto:vguemas@ic3.cat), [f.doblas-reyes@ic3.cat](mailto:f.doblas-reyes@ic3.cat)

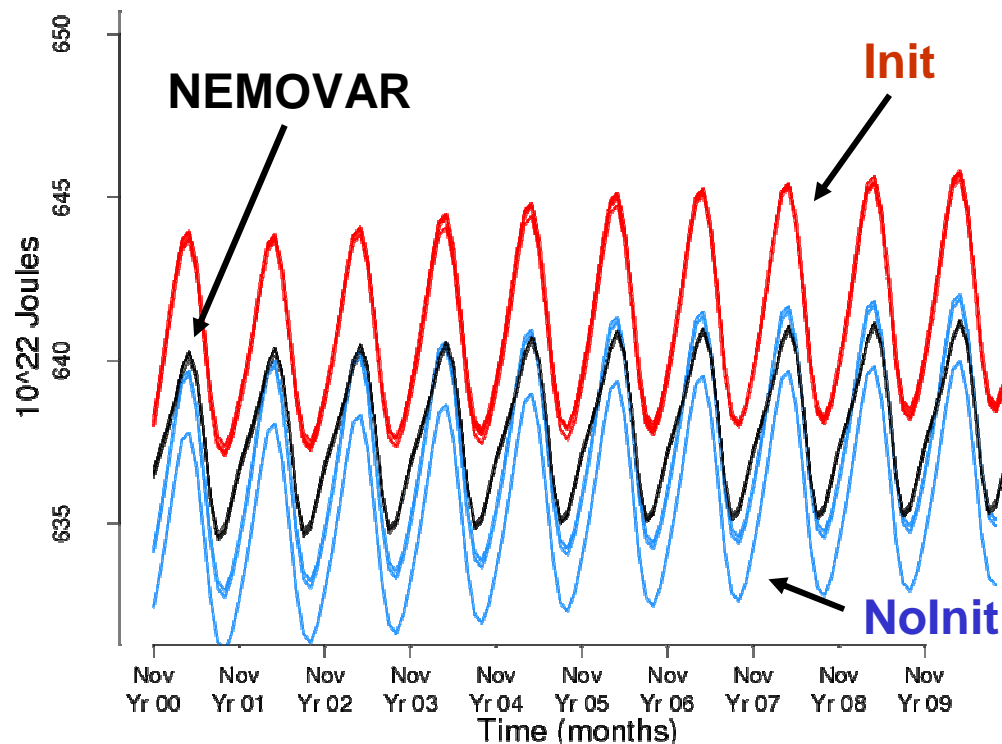
## Conclusions

- Initial warm bias – Austral ocean warm bias already during 1<sup>st</sup> year – Pronounced cold tropical bias 2-5 years
  - Better performance during the last decade – ARGO profiles
  - Benefit from initialisation detected with yearly hindcasts on
    - 1) Global SST up to 2<sup>nd</sup> year
    - 2) AMOC up to 3rd year
    - 3) Ocean heat content during the first 3 years (not shown)
- => correspond to the timescales of the drift
- Particularly poor AMV skill, only significant during the first year, mainly due to its subpolar branch (not shown)
  - Particularly poor results in the Arctic : crucial need for improved sea ice initial conditions
  - New set of initial conditions being produced and tested with additional ocean nudging and wind stress perturbations

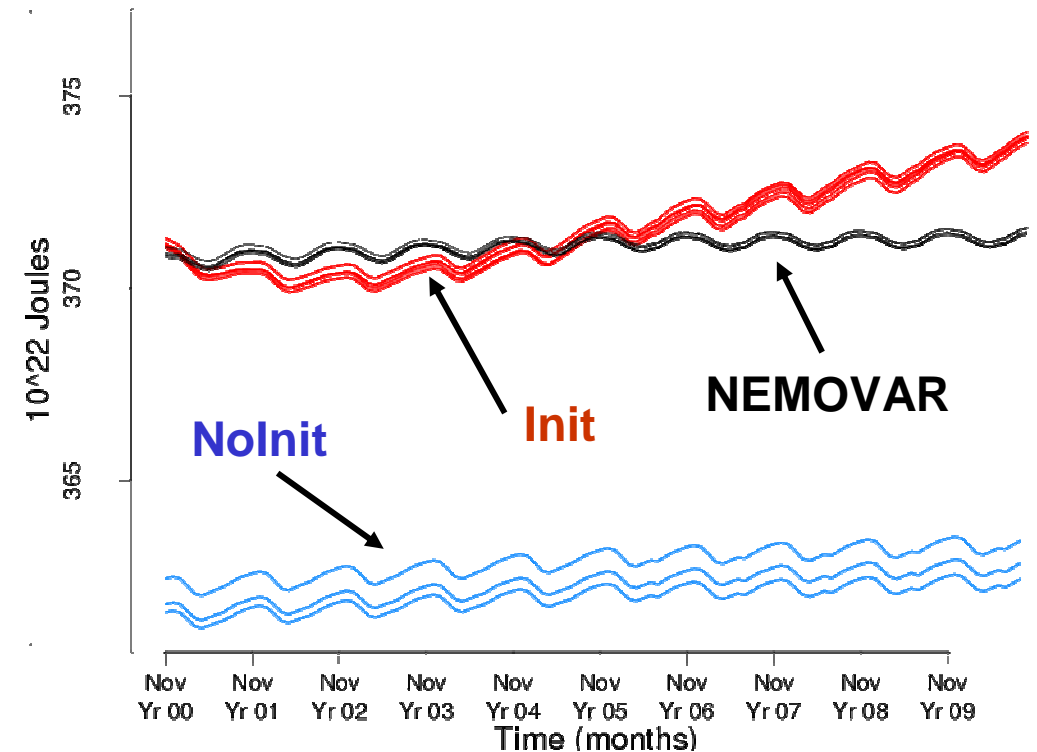
# Global ocean heat content

Climatology

global OHC 0-350m



global OHC 350-800m

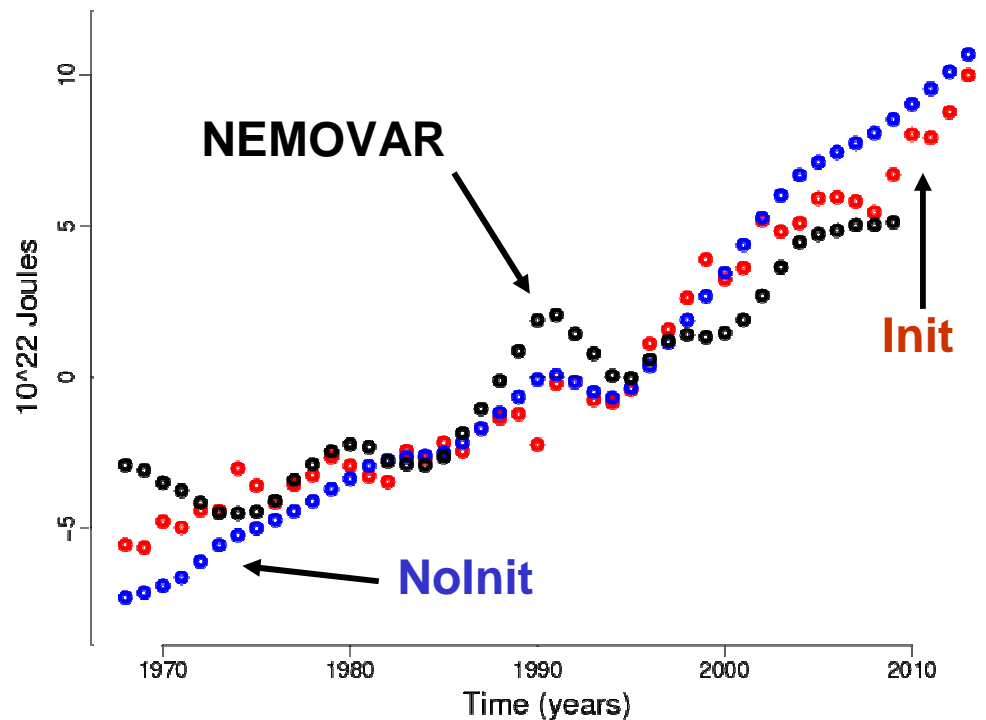


➡ Init global ocean heat content far from equilibrium

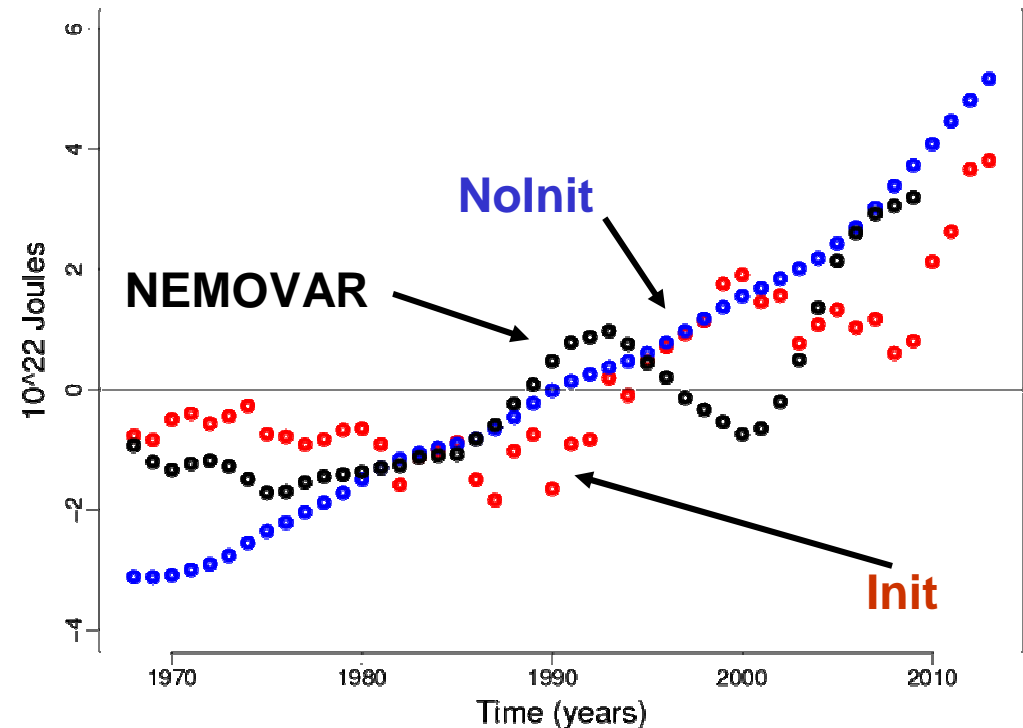
# Global ocean heat content

Anomalies : Forecast times 6-9 years

global OHC 0-350m

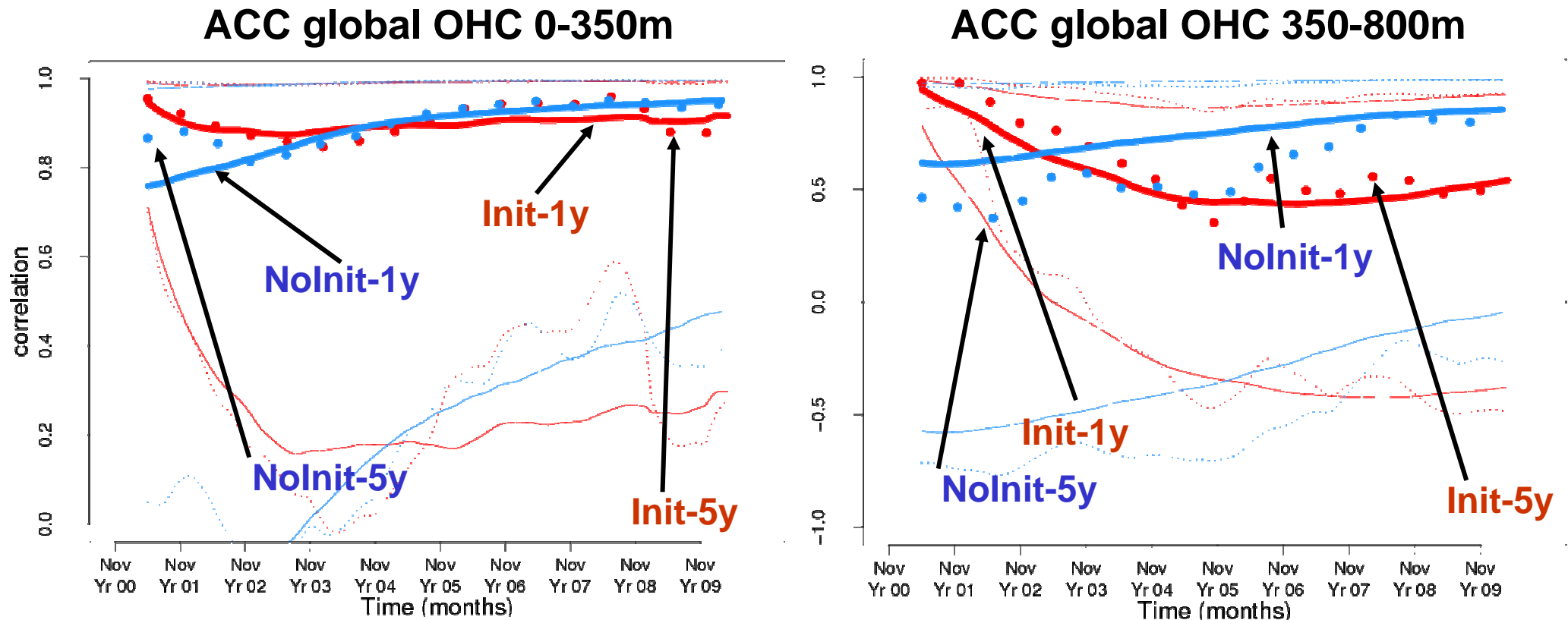


global OHC 350-800m



Significant skill in heat content all along the hindcast in the top layer, during the first three years in the 350-800m layer

## Global ocean heat content

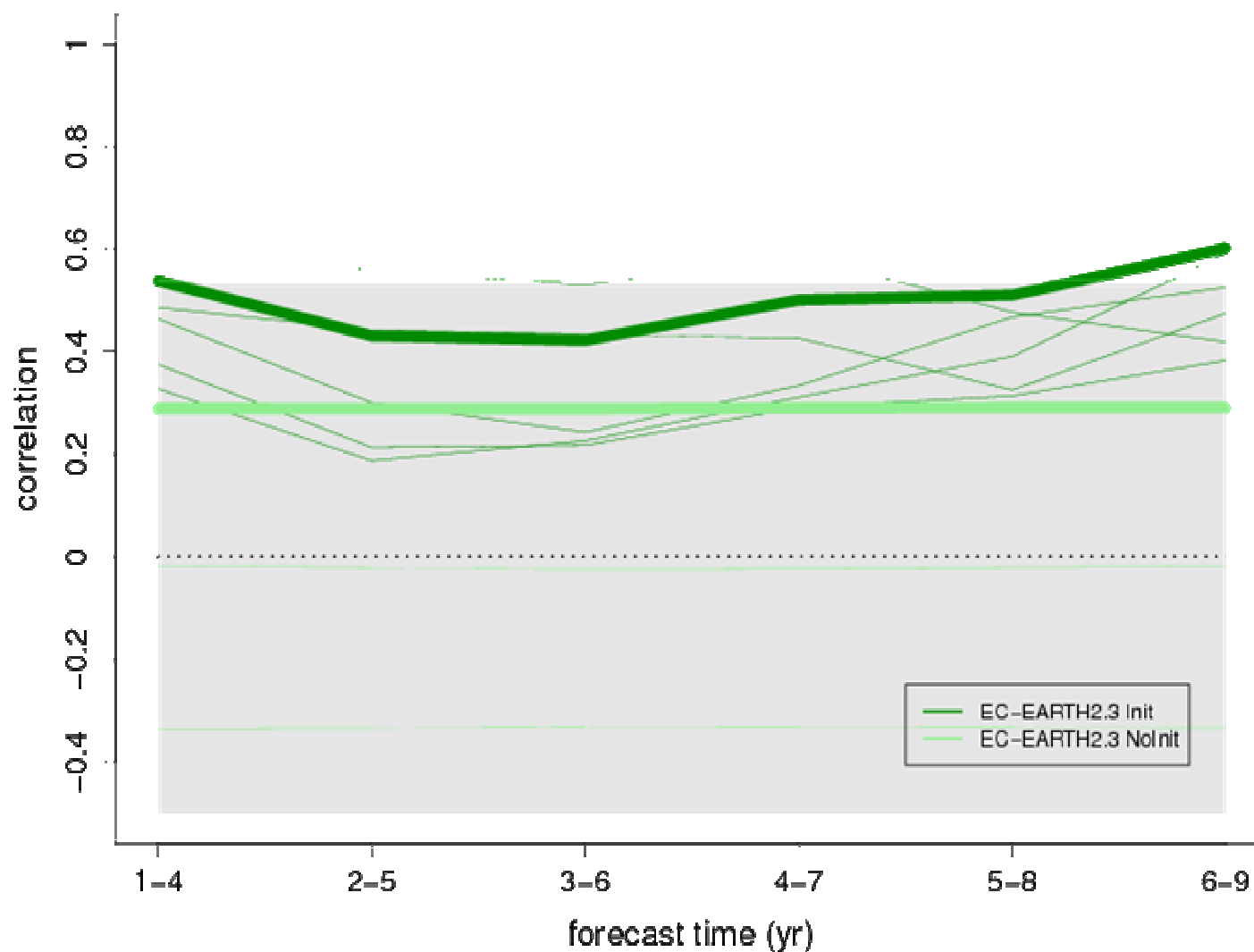


**Significant skill in heat content all along the hindcast in the top layer, during the first three years in the 350-800m layer**



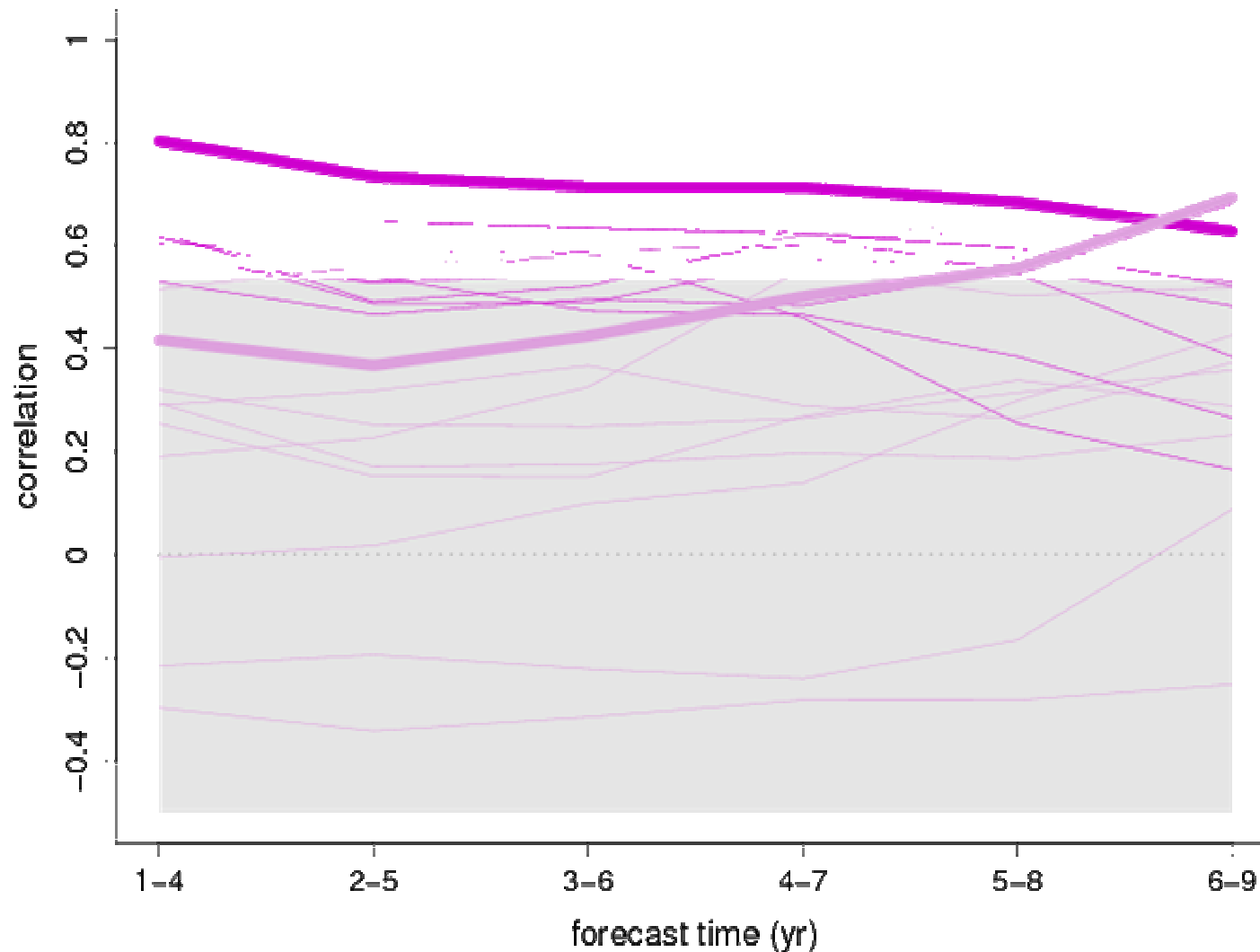
AMV correlation for ensemble mean and single-member EC-Earth  
yearly start date predictions.

AMO-index forecast skill / annual-mean (Jan-Dec)



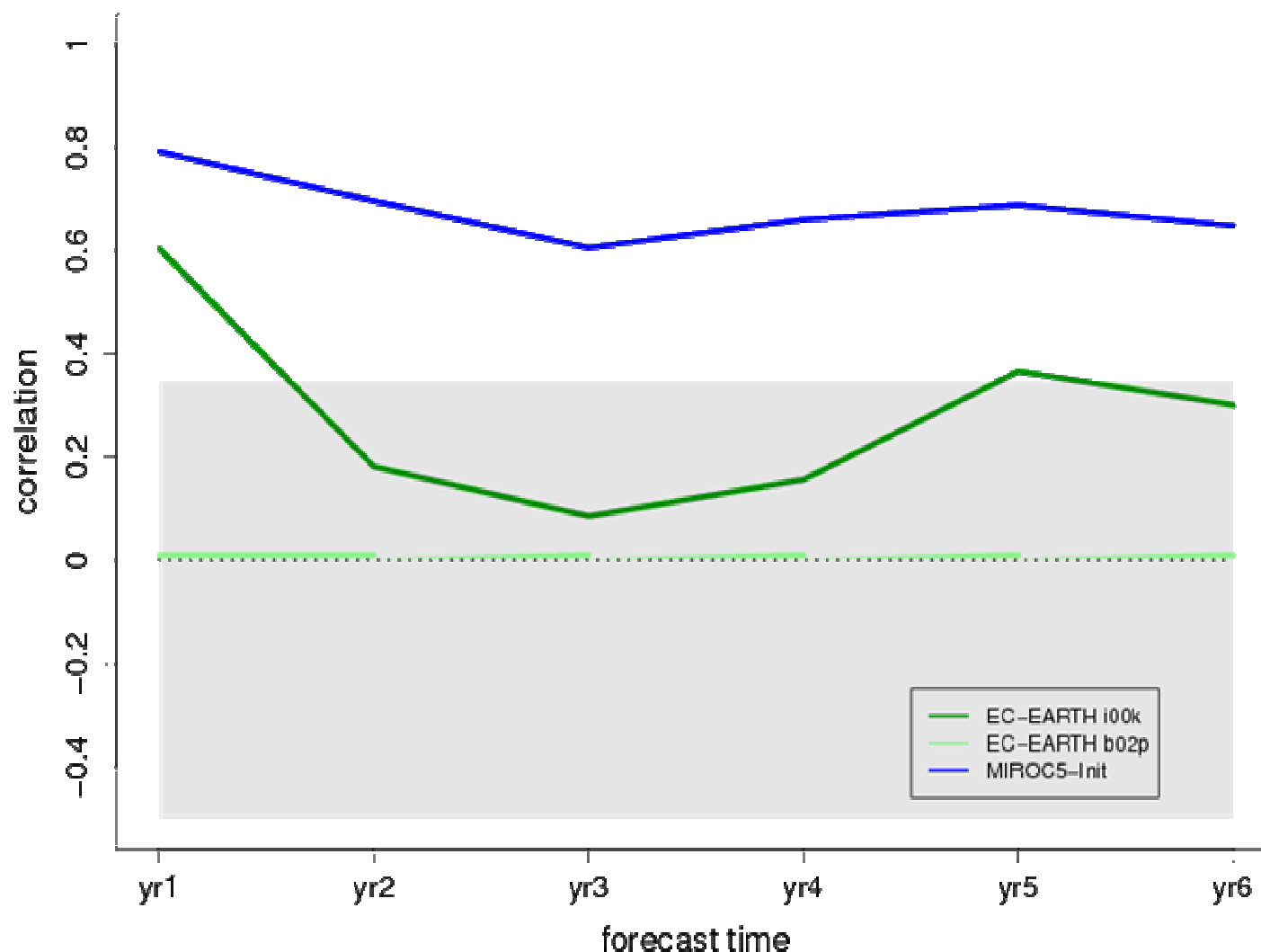
AMV correlation for ensemble mean and single-member DePreSys  
yearly start date predictions (Assim purple, NoAssim pink).

**AMO-index forecast skill / annual-mean (Jan-Dec)**



AMV-subpolar index correlation for ensemble mean EC-Earth and MIROC5 yearly start date predictions.

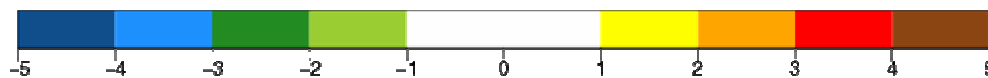
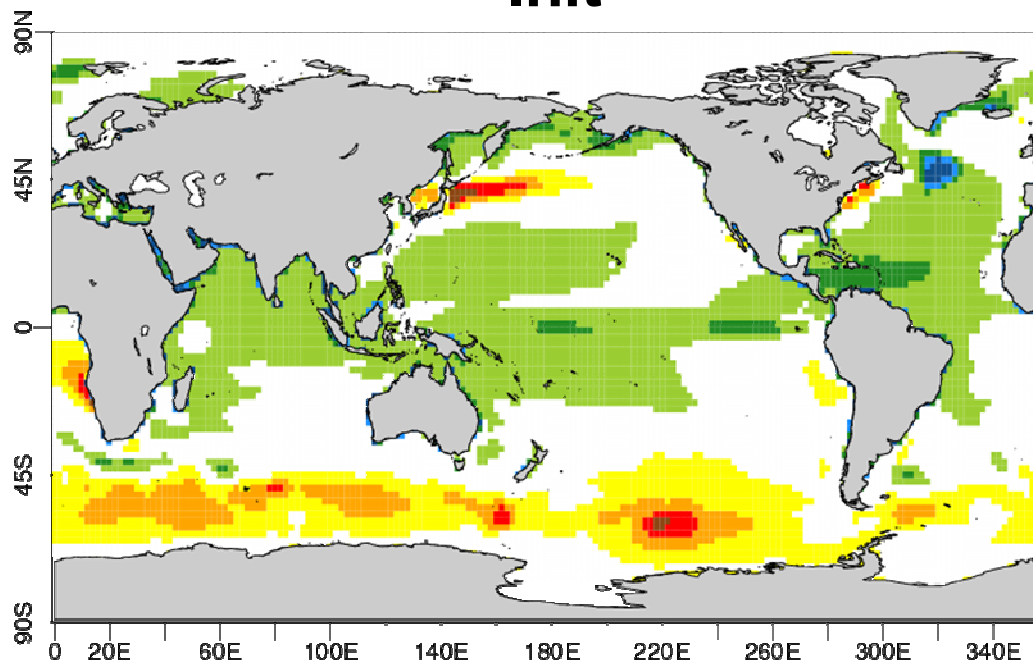
AMO-SP forecast skill / annual-mean (Jan-Dec) / pp1.1961-2006



# Sea Surface Temperature **bias** - yearly hindcasts

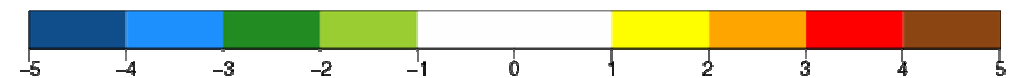
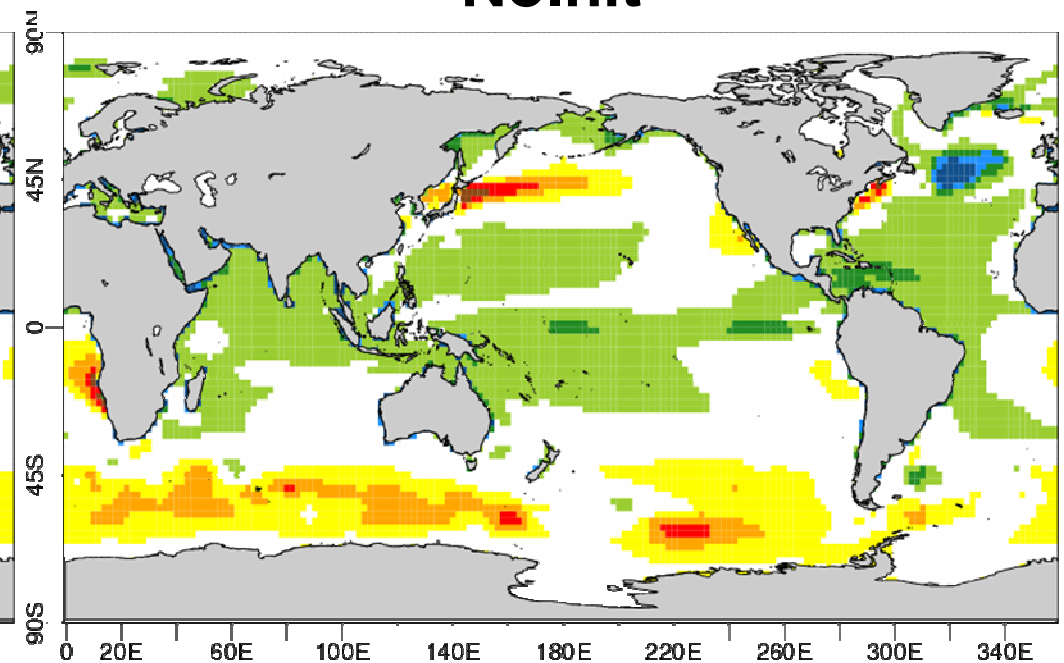
## Forecast time : 6-9 years

Init



Bias (K)

Nolnit



Bias (K)



Convergence of Init bias toward Nolnit one